which were spread in a most graceful manner, each feather vibrating in a way that almost dazzled the sight. During this display the bird would become greatly excited, and sometimes turn almost under the perch or branch, the head and neck being bent so low down."

Reading this, which was apparently written from memory for Elliot's Monograph, we get no idea of the position of the plumes, but the last lines shew that Bartlett must have witnessed the final stage of the display, which has been fully described above and figured.

It may be worth noting that when scratching their heads the Birds-of-Paradise, like other Passeres, bring the foot over the wing and side-plumes, although the operation is apparently conducted with some difficulty. Under the circumstances we should almost have expected these birds to adopt the more simple mode employed by other birds, such as Parrots.

At my suggestion, Mr. W. P. Pycraft has made a careful examination of the dermal muscles which control the side-plumes in *P. minor*, *P. apoda*, and allied forms; and the results of his investigations will be found in the memoir following.

XXVII.—*On the Pterylography and Dermal Myology of the Lesser Bird-of-Paradise, with especial reference to the "Display."* By W. P. Pycraft, F.Z.S., A.L.S., &c.

Introductory.

When Mr. Ogilvie-Grant suggested to me that I should endeavour to explain the mechanism by which the extraordinary display of *Paradisea minor* is effected, so as to form a supplement to his own paper on the subject, I had unfortunately no example of that species at hand for examination. Through the kindness of Mr. Beddard, however, this matter was soon remedied by the loan of a specimen in spirits from the collection under his charge at the Prosectorium of the Zoological Society. The complement to this

was furnished by the British Museum, in an example of *Paradisea apoda*. The result of a comparison of the specimens of the two species shews that they are practically identical both as concerns their myology and pterylosis. Such small differences as do exist will be pointed out in due course.

Naturally, in working out this question, I compared the muscles of *Paradisea* not only with those of such of its near relatives as I could obtain, but also with the more distant allies, or supposed allies, of the Birds-of-Paradise *. For an opportunity of examining *Ptilorhis paradisea* I have also to thank Mr. Beddard, who kindly sent me a specimen from his stores at the Prosectorium.

From the nature of this investigation it was obviously impossible to ignore questions of pterylosis: and since so little is really known on the subject, Mr. Grant and I feel that this opportunity may well be taken to describe in detail the disposition of all the feather-tracts, of *Paradisea* at least, and not merely those which are directly concerned with the display.

Hitherto the only published accounts on this subject appear to be the very brief and insufficient descriptions of Nitzsch and Giebel, which will be more particularly reviewed later.

Pterylography.

Pteryla capitis (text-fig. 28, p. 444, *pt.cap.*).—This is a densely feathered area, even the usual interramal space being absent.

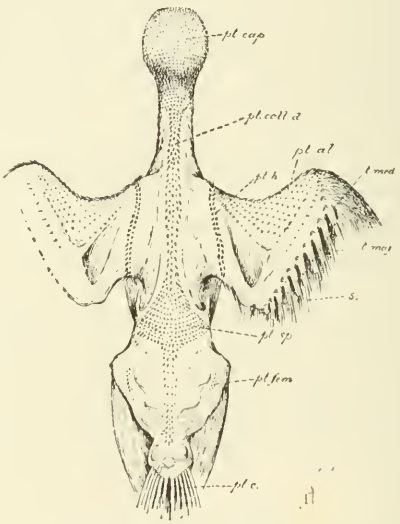
Pt. colli dorsalis (text-fig. 27, p. 442, *pt.coll.d.*).—The upper part of this tract turns downwards to blend with the *pt. colli ventralis*; rather below the middle of the neck, after the two tracts have regained their independence, the dorsal tract passes on to a broad ridge of skin, the feathers imbedded in which are very strong. Passing backwards, this ridge merges with the :—

Pt. spinalis (text-fig. 27, *pt.sp.*).—This tract, at a point a

* I have carefully compared the dermal muscles of *Paradisea apoda* with those of *P. minor*, *Ptilorhis paradisea*, *Ptilonorhynchus violaceus*, and *Sericulus melinus*.

little behind a transverse line drawn across the body at the post-patagium, gradually spreads out to form a fan-shaped shield, overlapping on to the pre-ilia. The remaining portion of the tract, caudad of the rounded free edge of the fan, is continued back to the oil-gland as a fairly wide and strongly-marked tract.

Text-fig. 27.



Dorsal view of *Paradisea minor*, shewing the feather-tracts.

pt. cap.= pteryla capitis; *pt. al.*= pt. alaris; *pt. c.*=pteryla caudalis; *pt. coll.d.*=pteryla colli dorsalis; *pt. fem.*=pteryla femoralis; *pt. h.* =pteryla humeralis; *t. maj.*=tectrices majores; *t. med.*=tectrices mediæ; *pt. sp.*=pteryla spinalis. *s.*=secondaries.

Pt. colli ventralis (text-fig. 28, *pt.c.v.*).—This tract does not acquire an independent existence until nearly halfway down the neck, being continuous above with the *pt. coll. dorsalis*.

Near the middle of the neck, in the mid-ventral line, it divides into two branches, strongly developed and passing into the:—

Pt. ventralis (text-fig. 28, *pt.vent.*).—From the base of the neck this passes backwards to form a spoon-shaped tract of considerable size. The outer border thereof is continuous

with that of the underlying pectoral muscle, at least as far as the axilla, where the free edge of the tract passes forwards and inwards to the shoulder-joint.

The feathers which make up this portion of the tract are those which form the superb plumes used in the display described by Mr. Grant. They are densely packed at their roots, and arranged, as may be seen in the figure, in more or less perfectly obliquely transverse rows, sloping from above backwards and downwards. By the contraction of the muscles described later, the whole of this tract is drawn upwards and forwards (headwards) so as to approach as nearly as possible to the back.

The inner branch of the *pt. ventralis* is moderately broad and continued backwards to the cloaca.

Pt. femoralis (text-fig. 28, *pt.fem.*).—This is primitive in character, being made up of delicate semiplumes—which are really degenerate contour feathers,—extending forwards to the outer branch of the *pt. ventralis*, upwards to the *pt. spinalis*, and downwards to the *pt. cruralis*. Running across the middle of the thigh is a narrow tract of relatively large feathers, and this, at first, appears to be all that remains of the femoral tract.

Pt. cruralis (text-fig. 28, *pt.cr.*).—The feathers of this tract are scattered thinly over the whole shank and are of a loose texture.

Pt. humeralis (text-fig. 27, *pt.h.*).—This is a long and unusually narrow tract, extending from the shoulder to the lower $\frac{1}{3}$ of the humerus.

Pt. alaris (text-fig. 27, *pt.al.*).—The wing is eutaxic. There are 10 primaries (the 10th remex being very long) and 11 secondaries (the 11th feather is, however, vestigial and hardly to be distinguished from its covert). Both carpal covert and remex are present.

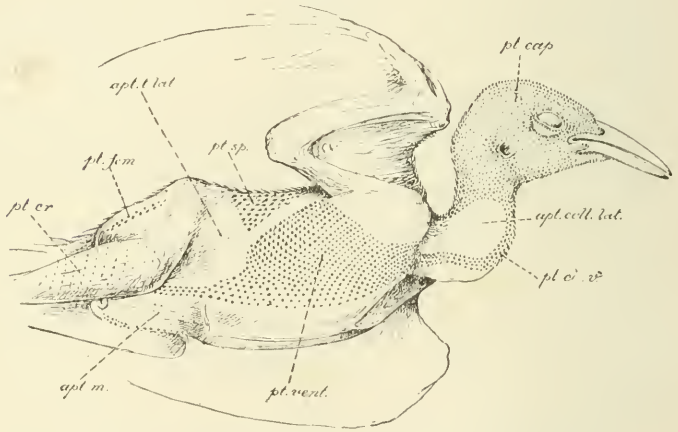
Tectrices.—Only the coverts of the upper surface demand notice here; those of the ventral surface are reduced to the condition of semiplumes, save the *t. majores* and *t. minores.*

T. majores.—The free edges of the secondary coverts of this series are not continuous with those of the primaries.

T. mediæ.—These are small feathers, calling for no special description; as in *Corvus*, for example, a wide space separates these coverts from the :—

T. minores.—Only one row of these coverts appears to be present; as we have just remarked, these are cut off from the *t. mediæ* by a broad apterion, and this extends back to the elbow, and forwards along the humerus, being bounded by the biceps tendon immediately beneath.

Text-fig. 28.



Side view of *Paradisea minor*, showing the feather-tracts.

pt. cap.=pteryla capitis; *pt. c. v.*=pteryla colli ventralis; *pt. cr.*=pteryla cruralis; *pt. fem.*=pteryla femoralis; *pt. sp.*=pteryla spinalis; *pt. vent.*=pteryla ventralis. *apt. coll. lat.*=apterion colli laterale; *apt. t. lat.*=apterion trunci laterale; *apt. m.*=apterion mesogastræi.

Parapteron.—Owing to the short humerus this is represented only by some six tiny semiplumous feathers wedged in between the *pt. humeralis* and the secondaries.

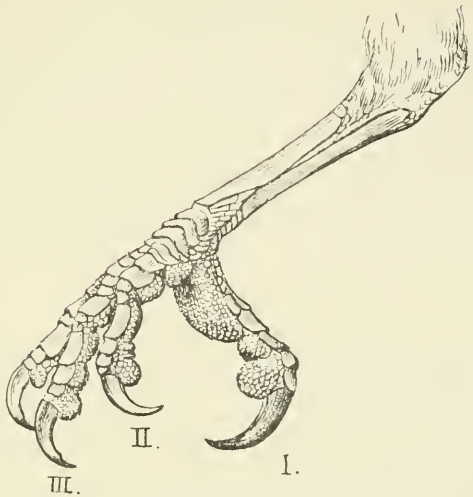
Aftershaft.—This is wanting.

Filo-plumes.—About three of these feathers occur at the base of each contour feather; they are of considerable length along the spinal tract, but do not develop a vane.

Oil-gland.—Naked and nipple-shaped.

Rhamphotheca.—The tomium is entire; the nostrils open at the extreme base of the beak and are concealed by feathers.

Text-fig. 29.



Side view of foot of *Paradisea minor*, to shew the scales of the acrotarsium and planta.

Text-fig. 30.

Sole of right foot of *Paradisea minor*, to shew the syndactyle condition of the middle and outer toes.

Acrotarsium.—This is covered by three large shields; of these the proximal is of great size; beneath these are two small scutes which overlap the bases of the toes.

Planta.—The planta is covered by one great shield, laterally compressed to form a sharp keel along the outer border of the planta.

The hallux is of great size, much longer than the front toes. The middle and outer toes (text-fig. 30, p. 445), it is to be noted, are united at their bases, so that the foot may well be described as syndactyle.

Comparative Remarks.

The pterylological characters of *P. apoda* and *P. minor* are practically identical; but before any result of real value on this subject can be obtained, a large series of specimens of these and other species and genera must be examined.

I have been able to examine only a single specimen of each of *Ptilorhis paradisea* and *Manucodia comrii*, and (among the supposed allies of the Paradise-Birds) of *Ptilonorhynchus violaceus* and *Sericulus melinus*.

Ptilorhis is characterized by a rhombic saddle to the *pteryla spinalis* and a long, narrow, outer branch to the *pt. ventralis*, barely diverging from the inner branch at its extreme end. In *Manucodia* the saddle is spindle-shaped, and the free end of the outer branch of the *pteryla ventralis* is, though narrow, wider than in *Ptilorhis* and more distinct therefrom.

Ptilonorhynchus and *Sericulus* differ from the Birds-of-Paradise in that the saddle of the spinal tract encloses a space as in the Corvidæ. The ventral tract has the outer branch narrow and well separated from the inner.

Dr. C. G. Giebel, in 1877 *, contributed a few short notes on the subject of the pterylosis of the Birds-of-Paradise, based, however, upon an examination of skins only. His observations, therefore, are necessarily of no great value. He accompanied his remarks with small diagrams of the

* Giebel, Zeitschr. f. ges. Naturwissensch. xlix. 1877, p. 143.

ventral tracts of "*Seleucides alba*," *Epimachus superbus*, *E. regius*, and *Diphyllodes magnifica*.

The differences between the two species of *Epimachus* are surprisingly great, if these figures are correct, and still more striking is the form of the spinal tract in *Diphyllodes*, which, according to the figure, resembles that of the Hirundinidæ!

Nitzsch *, some years earlier, described very briefly the spinal and ventral tracts of *Paradisea apoda*, *Epimachus superbus*, *E. regius*, and *Ptilonorhynchus holosericeus* (*violaceus*).

Epimachus superbus he found to differ from *Paradisea* in that the spinal tract lacked the broad "saddle"; it resembled *Paradisea* in that the outer branch of the ventral tract passed insensibly into the inner, while in *E. regius* it terminated freely as in *Ptilonorhynchus*. The saddle of *E. regius*, it is curious to note, was cordate and bilobate posteriorly.

The Skin-muscles, and how they affect the Display.

The display so vividly described by Mr. Grant is effected, of course, by the harmonious working of a very complex mechanism, but we are concerned here only with certain agents thereof—the action of certain muscles underlying the skin.

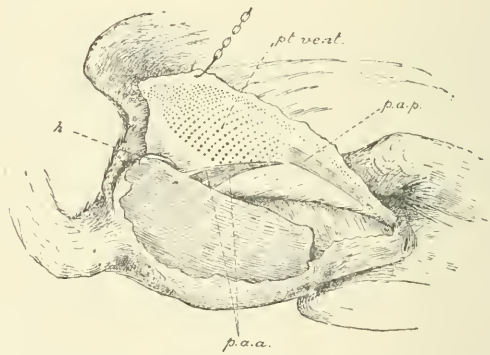
The most important is one which, arising by a double head from the side of the great pectoral muscle—described later as the *pectoralis abdominalis pars anterior*,—is inserted into the lower end of the great crowded mass of feathers which forms the outer branch of the ventral tract. When this muscle, under excitement, contracts, it necessarily draws the roots of the mass of plumes concerned upwards and forwards nearer the top of the back and towards the head. So long as this muscle remains tense the feathers will remain erect. After the display they are drawn downwards by the contraction of a long band of muscle arising from the groin and inserted into the end of the mass of plume-roots. The

* Nitzsch, "Pterylography," Engl. Transl., Ray Soc. 1867.

shaking of the plumes is probably effected by rapid waves of contraction and expansion of the erectile muscles; and this is aided by strands of minute muscle passing from feather to feather.

The excessive development of muscular tissue beneath the skin of the neck, by which the skin becomes thrown into innumerable tiny rugosities and folds, is hard to explain at present.

Text-fig. 31.



Side view of dissection of *Paradisea minor*, to shew the dermal muscles used for the purpose of erecting the lateral plumes.

pt. vent. = pteryla ventralis; *p.a.a.* = pectoralis abdominalis pars anterior; *p. a. p.* = pectoralis abdominalis pars posterior; *h* = head of humerus.

The following more technical description of these and other muscles may prove of value for morphological purposes.

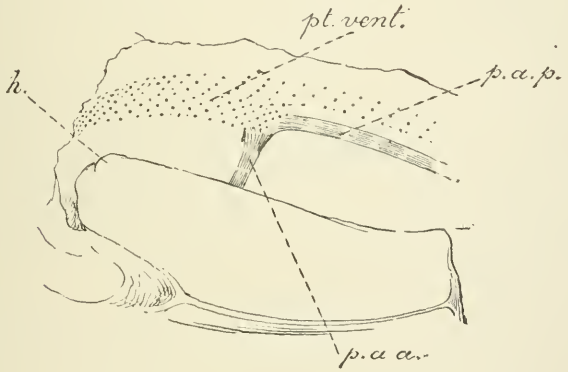
Myology.

Only those muscles will be described here which are more or less directly concerned with the production of the display. The nomenclature adopted, unless otherwise stated, is that of Fürbringer. This description, it should be remarked, is based on specimens preserved in spirit in the British Museum and the collections of the Zoological Society of London.

Cucullaris dorso-cutaneus.—This muscle, a derivative of the *cucullaris*, is in *Paradisea minor* and *P. apoda* well

developed. It rises, in common with, but dorsad of, the *cucullaris propatagialis*, from the wall of the skull immediately behind, and slightly above the postorbital process; expanding upwards and backwards to the middle line, it covers the base of the skull, and thence runs back immediately under the skin, at first as a broad sheet, but rapidly tapering it assumes a narrow band-like form, and just caudad of the scapula fuses with the *latissimus dorsi dorso-cutaneus*. Being closely attached to the under surface of the *pteryla colli dorsalis* and *spinalis* on either side, it serves, on contraction, to raise the dorsal feathers of the neck and fore part of the back. By its contraction, in the spirit-specimen, the skin is thrown into a number of fine wrinkles.

Text-fig. 32.



Side view of a dissection of *Sericulus melinus*, shewing the muscles corresponding to those drawn in text-fig. 31. Note that the pars anterior has but one head, answering to the hinder head seen in *P. minor*.—Letters as in text-fig. 31.

Latissimus dorsi dorso-cutaneus.—This muscle is also well developed. It arises fleshy from the anterior border of the pre-ilium and extends forwards along the border of the *pteryla spinalis* until it ultimately passes into the *cucullaris dorso-cutaneus*.

Cucullaris pars cervicalis.—Arising from the expanded free end of the clavicle, caudad of the tendons for the *tensor*

patagii and *deltoid*, it passes upwards over the base of the neck, and at the same time expands to form a broad sheet of muscle triangular in shape, and split up to form some half-dozen narrow bands separated by narrow interspaces one from another. These are inserted in the skin along the inner border of the *cucullaris dorso-cutaneus*. *Action*: all these strands slope tailwards, so that their contraction draws the skin forwards.

Pectoralis abdominalis.—This muscle we must regard as divided into two parts, corresponding to the *pars anterior* and *pars posterior* of Fürbringer—the *subcutaneus thoracis* and *subcutaneus abdominalis* of Gadow.

The *pars posterior* arises from the pubis in the usual manner, but in the form of an extremely delicate tendinous band, which, near the middle of the abdomen, becomes suddenly fleshy and is inserted into the free end of the outer branch of the *pteryla ventralis*.

The *pars anterior* is two-headed. The more caudad answers to the normal head and arises from the dorsal border of the *pectoralis* near its sternal edge. The second head arises *cephalad* of this, from the external fibres of the *pectoralis major* at the axilla; the two heads fuse to form a broad band inserted into the dorsal border of the outer branch of the *pteryla ventralis*.

Action: These two muscles owe their independence to the suppression of the band at its middle; thereby greater facilities are gained for raising and depressing the long pectoral plumes in display. Contraction of the *pars posterior* depresses the plumes: conversely, by the contraction of the two heads of the *pars anterior* these plumes would be raised and at the same time drawn upwards and thrown slightly forwards.

Serratus superficialis pars metapatagialis.—This is a long band-like muscle arising ventrad of the *serratus superficialis posterior*, from the base of the uncinate of the fourth thoracic rib; extending upwards and forwards it is inserted into the hinder end of the *pteryla humeralis* instead of continuing its course outwards to the elbow.

Comparative Myological Remarks.

I have carefully compared the dermal muscles of *Paradisea minor* with those of its near allies *P. apoda, Ptilorhis paradisea,* and *Manucodia comrii,* as well as—for the sake of shewing the range of variation of the muscles in question—with *Ptilonorhynchus violaceus, Sericulus melinus, Corvus corone,* and *Pityriasis gymnocephala.*

Paradisea minor and *P. apoda* differ only in that the two heads of the *pectoralis abdominalis pars anterior* are inserted nearer together in *P. minor* than in *P. apoda.* The close relationship which obtains between these two forms naturally leads one to expect but slight differences in this matter. The accessory head of the *pars anterior* is found only in these two species, and is to be attributed to the enormous development of the pectoral plumes which these muscles have to drag upwards and forwards and hold in position during the display.

The *pectoralis abdominalis* is normally formed by a single band of muscle extending from the pubis, and running along at first beneath the inner branch of the *pteryla ventralis* it turns upwards and crossing the free end of the outer branch of this tract it is ultimately inserted into the dorsal border of the *pectoralis* in the region of the axilla. Thus it will be found in *Corvus.* In *Ptilonorhynchus* and *Sericulus* this band breaks up into two, connected only by a few slender fibres. The posterior part, as will be seen in text-fig. 32 (p. 449), becomes firmly attached to the free end of the outer branch of the *pteryla ventralis*; the *pars anterior* similarly becomes attached to a slight angulation of the dorsal border of this feather-tract.

In *Sericulus* the *pars anterior* and *pars posterior* are somewhat less distinctly separated, the divided ends being placed closer together to form a sharp angle with one another (text-fig. 32).

In *Manucodia comrii* and *Pityriasis gymnocephala* the variation is slightly more marked. In the first-mentioned the outer branch of the *pt. ventralis* turns slightly upwards,

and into the dorsal and ventral angles of the free end these two portions of the *abdominalis* are inserted. The *pars posterior* fixes itself into the ventral angle, the *pars anterior* into the dorsal angle.

In *Pityriasis* the *pars posterior* is inserted into the free end of the region of the tract now under discussion, and the *pars anterior* crosses over this insertion so as to become attached to the postero-internal angle of the tract.

Latissimus dorsi dorso-cutaneus.—This is exceptionally well developed in *Paradisea*; but the same peculiarities which obtain in this genus are met with also in *Ptilonorhynchus* and *Sericulus*; in these genera, however, the muscle is but feebly developed. In *Manucodia comrii* this muscle merges with the *cucullaris* (*pars cranialis*) cephalad of the *dermo-cleido-dorsalis* (*cucullaris pars cervicalis*), at the point where it (*pars cranialis*) turns downwards to its insertion on the clavicle.

Summary.

Though the foregoing detailed descriptions of the pterylosis and dermal myology of the genus *Paradisea* are more complete than any hitherto published, there are yet several matters to be cleared up; and still more remains to be done in the case of other genera.

In so far as *Paradisea* and its display is concerned, I feel that I have been able to add but little to the interest of Mr. Grant's vivid descriptions. The dissecting-table is not the channel through which phenomena like these can be studied.

As touching the pterylosis of *Paradisea*, I would point out the necessity of examining females with a view to ascertaining whether in them the outer branch of the ventral tract is similarly enlarged, and also whether the accessory slip to the muscle attached to this tract is present.

From what I have seen in the course of the preparation of this paper, I am inclined to believe that the Birds-of-Paradise are by no means so closely related to the Corvidæ or to the Ptilonorhynchidæ as is generally supposed at the present

day. The results of a further examination of the question I hope to submit to the readers of 'The Ibis' in the near future.

Some years ago Mr. J. G. Goodchild, in his paper on the "Cubital Coverts of the Euornithes"*, contended that the Birds-of-Paradise were unique among the Passeres in that they lacked median coverts. He relied, apparently, solely on the overlap of the feathers. A more thorough examination of the wing shews that Mr. Goodchild was mistaken in this matter. The wing is of the normal Passerine type, though it may possess certain peculiarities of overlap. This point, from lack of fresh specimens, I have been unable to determine. The evidence from skins is absolutely unreliable on this subject.

XXVIII.—*On a small Collection of Birds from the Wadi-en-Natrûn, Egypt.* By W. L. S. Loat, F.Z.S.

The Wadi-en-Natrûn, or Natron Valley, of Egypt is situated in the Libyan Desert about seventy miles W.N.W. of Cairo, and sixty miles nearly due south of Alexandria †. The valley, which is twenty-one miles in length from end to end, lies approximately W.N.W. by E.S.E., and contains a chain of ten alkaline lakes yielding the natron from which the soda-ash of commerce is obtained. Scattered throughout the Wadi are a number of freshwater pools, generally more or less surrounded by a dense growth of a species of papyrus, locally known as "bourdy," which also covers large tracts of the marshy ground, forming, in fact, nearly ninety per cent. of the vegetable growth found there. Tramping through these marshes is by no means pleasant, as the ground under foot generally consists of soft black mud, which in places gives off sulphuretted hydrogen at every step. On the higher ground are stretches of sand-hills sparsely

* "The Cubital Coverts of the Euornithæ in relation to Taxonomy," Proc. Roy. Phys. Soc. Edinb. vol. x. (1888–90).

† These distances are taken from the centre of the Wadi.